PLACENTATION OF THE PIGMY TREESHREW TUPAIA MINOR

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The Bornean Zoological Expedition of Chicago Natural History Museum collected three pregnant uteri of the pigmy treeshrew, *Tupaia minor*. In view of the important position of the Tupaiidae at, or at least near, the base of the primate line, information on the several species composing this family is extremely desirable. The fetal adnexa of the treeshrews are very inadequately known, and have not hitherto been examined from the standpoint of modern concepts.

The pigmy treeshrew is the smallest of the treeshrews. The average head and body length is about 130 mm., and adult animals weigh about 50 grams. The species occurs in Borneo, Sumatra, and the southern part of the Malay Peninsula. Its relationships to other species of the genus *Tupaia* are unknown.

Amniogenesis and the morphogenesis of the placenta in *Tupaia javanica*, a small long-tailed Javanese species, were described and figured many years ago by Hubrecht (1895, 1899). De Lange and Nierstrasz (1932) reviewed the placentation of *Tupaia javanica* very briefly, adding little to Hubrecht's data. Recently van der Horst (1949) redescribed the placentation of *Tupaia javanica*, partly from a re-examination of Hubrecht's slides and partly from newly sectioned material from the Hubrecht collection. Van der Horst challenged many of Hubrecht's interpretations, replacing them with unique and most extraordinary interpretations of his own. Van der Horst's views differ not only from those of Hubrecht, but from those of all other students of the mammalian placenta.

MATERIAL AND METHODS

The material on which this study is based was collected in the vicinity of Sandakan, North Borneo, in 1950. Two uteri represent pre-implantation and early blastocyst stages of pregnancy, respectively, while a third was near term (C-R length of fetus 29 mm.). The intact uteri were preserved in 10 per cent formalin in the field,

and were transferred some months later to 68 per cent alcohol. The reproductive tract of the advanced pregnancy was preserved *in situ*.

Each specimen was first dissected, using a 9X binocular microscope where necessary. Tissues for histological study were removed, embedded in paraffin, and serially sectioned at 8–10 micra. All sections were stained with hematoxylin-eosin.

OBSERVATIONS

Morphology of Reproductive Organs

Gross structure.—The female reproductive organs of *Tupaia ferruginea* (= *T. glis*) were described very briefly by Jones (1917), and except for brief notes by earlier workers this is the only description of these organs in the Tupaiidae. *Tupaia glis* is a much larger species than *T. minor*.

The uterus is bicornuate in *Tupaia* and very similar to that of the Insectivora in gross form. In the early stages of pregnancy it consists of a short median corpus and two elongate horns (pl. 10, fig. 1), and bears only a general resemblance to the figures given by Jones. The corpus consists largely of an elongate massive cervix, which projects prominently into the vagina, leaving deep fornices at the proximal end of the vagina. The corpus measures about 7 mm. in length (to the distal end of the cervix).

The lining of the cervical canal is thrown up into longitudinal rugae, while the lining of the uterine part of the corpus is smooth. The cornua are short and stout, measuring about 7 mm. in length by 4 mm. in diameter.

The oviduct is a relatively long, slightly contorted tube enclosed between the two layers of the broad ligament. It measures about 15 mm. in length by about 1 mm. in diameter and is curved in a loop that almost completely encircles the ovary. The infundibulum lies at the proximal pole of the ovary. It has a funnel shape, is provided with short fimbriae, and is attached to the ligament near the entrance to the bursa ovarica.

The ovary is a flattened triangular body about 2 mm. in greatest diameter, the apex lying adjacent to the infundibulum. The ovary is enclosed in a peritoneal recess (the ovarian bursa) that encloses both ovary and oviduct. The bursa communicates with the peritoneal cavity through a wide slit-like opening near the tip of the uterine horn.

The broad ligament is a triangular fold of peritoneum extending between the uterine horn and the ventro-lateral wall of the pelvis. The round ligament is a narrow fibro-muscular band lying in the lateral edge of the broad ligament. It reaches the pelvic wall in the region of the inguinal canal. The two round ligaments form an angle of about 60° when stretched. Beyond the round ligament the peritoneal fold is continued dorsad and mesad as a recto-uterine fold, to pass dorsal to the rectum where it continues as the short mesorectum. The two recto-uterine folds form a deep recto-uterine pouch.

In late pregnancy (pl. 10, fig. 2) the cornua are much enlarged and are thin-walled throughout their entire length. There are two fetuses, one in each horn, apparently near term; the crown-rump length is 29 mm. Each fetus lies with the head toward the uterine body, the belly directed toward the maternal midline. The head is flexed, the limbs are tightly pressed against the belly, and the tail is curved forward along the side of the body. The two parts of the placenta embrace the fetus on either side of its ventral midline. The fetuses are unpigmented; there are short dark vibrissae and a few long hairs are scattered over the body.

Histology.—A complete set of transverse serial sections of one uterine horn was cut, representing a very early stage of pregnancy. No trace of the blastocyst was found in the uterine cavity, indicating that the cleaving egg had not yet reached the uterus. The following description is based on this specimen (pl. 13, figs. 11, 12).

The myometrium is composed of a relatively thin outer layer of longitudinal muscle fibers and a much thicker inner layer of circular fibers. The uterine vessels are situated in the outer part of the circular muscular layer, where they form a relatively regular vascular sheet from which branches are sent to the endometrium.

The endometrium is as thick as the whole myometrial layer and is slightly furrowed. On opposite sides of the uterine cavity it contains the two cushion-like trophospongia (Hubrecht's terminology), the pre-implantation placental structures characteristic of *Tupaia*. The epithelial lining of the uterus consists of tall simple columnar cells that show no trace of cilia. Uterine glands penetrate the whole thickness of the endometrium and are sectioned in all directions. The uterine glands are cylindrical, not dilated at the fundus, and with no constriction at the neck. The glandular epithelium is of columnar or low cuboidal type; no cilia are present. There is no evidence of active secretion at either early or late stages of gestation. The glands are densely and evenly distributed through all parts of

the endometrium except in the trophospongia, which consists of dense endometrial stroma in which glands are wanting. There is a thin layer of uterine glands, flattened between the trophospongia and the myometrium, beneath the trophospongia; in some places the trophospongia is in direct contact with the myometrium, and in such places there are no glands and many vessels pass from the myometrium into the trophospongia.

The bursa ovarica enclosing the ovary is composed of a double layer of peritoneum containing blood vessels for the ovary. Its structure is similar to that of the uterine ligaments. The germinal epithelium on the surface of the ovary is of a tall simple columnar type. The cortex is densely packed with primary follicles. More mature follicles are situated deeper, protruding into the medullary zone. The medullary zone is composed of dense ovarian stroma with vessels; it contains a large corpus luteum of pregnancy and a relatively small corpus albicans (pl. 14, fig. 15).

The oviduct (pl. 14, fig. 17) has a muscular wall with a mostly circular arrangement of the fibers. The mucosa is thrown up into numerous folds that protrude into the lumen. The lining of the oviduct consists of tall simple columnar epithelium, which is ciliated.

Placenta and Fetal Membranes

The placenta is double discoidal, consisting of two sharply circumscribed kidney-shaped structures, approximately equal in size, each measuring about 18 × 8 mm. along the inner curvature. The two structures are attached to the dorsal and ventral walls, respectively, of the uterus. Implantation is bilateral, the two placental structures attaching on either side of the mesometrial line; their adjacent borders are only about 7 mm. apart. There is no macroscopically visible yolk sac. The umbilical cord is long, measuring about 20 mm. in length. It is untwisted and is flattened in cross section (pl. 14, fig. 18). A few millimeters before reaching the placentas the cord divides into two subequal funnel-shaped groups of umbilical vessels, one for each of the two placental structures. The vessels enter each placental structure from its anti-mesometrial side. No vessels pass across from one placental structure to the other.

The Blastocyst Stage

One uterine horn containing a pregnancy in the blastocyst stage was serially sectioned. The blastocyst was probably at an early

stage of implantation. It is in the uterine cavity, detached from the endometrium and partly destroyed by maceration (pl. 13, figs. 13, 14). The site of implantation may be identified by the presence of the developing syntrophoblast, eroding the uterine epithelium and penetrating into the uterine stroma at the site of the trophospongia.

The uterine wall is only slightly distended, compared with the earlier pregnancy shown in plate 13, fig. 11. The blastocyst is at the trilaminar stage of development. The trophoblast has both cyto- and syntrophoblastic proliferations. The two placental primordia are interconnected by a thin trophoblastic layer underlain by loosely arranged extra-embryonic coelomic mesoderm (pl. 13, fig. 14). The trophospongia, forming the decidua basalis of the developing placenta, consists of a dense, well-vascularized proliferation of the endometrial stroma. On the surface of the trophospongia the uterine epithelium is lost and the superficial layer of the stroma eroded, an obvious indication of the activity of the syntrophoblast at the site of implantation.

The yolk sac is a small bilaminar vesicle lying beneath the embryonic plate. In the embryonic hemisphere the embryonic plate is surrounded by undifferentiated extra-embryonic mesoderm; it is impossible to tell how far this mesoderm extended into the abembryonic hemisphere. There is no indication of amniogenesis.

The Late Fetal Stage

The chorio-allantoic placenta is of the hemochorial labyrinthine type. It is composed of a thin endometrial part, the decidua basalis (maternal), and a thick chorio-allantoic part (embryonic).

The *decidua basalis* is moderately thick, about one-seventh of the thickness of the entire placenta at its thickest part. It is composed of endometrial stroma, through which pass the endometrial arteries communicating with the maternal feeder channels. Atrophic uterine glands are scattered through the tissue of the decidua basalis and the decidua parietalis. The glandular epithelium is low, and there is no evidence of secretory activity. The uterine epithelium is completely lost on the surface of the decidua basalis but remains intact on the decidua parietalis, where it lies against the chorion.

The *trophoblast* is about five times as thick as the decidua. It is composed of a thin basal syntrophoblastic layer in contact with the decidua basalis, and a much thicker labyrinthine part. In several

places the placenta exhibits degenerative changes, consisting of localized deposits of fibrin in the trophoblastic tissue (pl. 11, fig. 5). The thickness of the basal layer varies, and in some places it is even interrupted.

The labyrinthine part of the trophoblast consists of a heavy meshwork of syncytium enclosing relatively narrow maternal sinuses. The sinuses are in wide communication with one another. Toward the margin of the placenta the meshwork becomes coarser, and isolated scattered lacunae appear. The fetal capillaries are enclosed in crude finger-like structures, not quite villi but certainly villus-like. Each villous structure is composed of a core of chorionic mesenchyme containing fetal capillaries, surrounded by a layer of syntrophoblastic tissue of varying thickness, and separated from adjacent villi by spaces filled with maternal blood. The spaces between the villi form a maze of irregular trophoblastic channels. Thus the actual barrier to fetal-maternal interchange consists of three fetal tissues: the syntrophoblast, the chorionic mesenchyme, and the endothelium of the capillary, and *Tupaia* clearly shows the *labyrinthine hemochorial relationship between maternal and fetal circulations*.

The large branches of the umbilical vessels on the fetal surface of the placenta ramify to and from the villi. The vessels penetrate into the depth of the placenta before breaking up into capillaries.

No giant cells were observed in this placenta.

There is no evidence that the allantoic vesicle reaches the fetal surface of the placenta.

The *yolk sac* consists of a large thin-walled bilaminar omphalopleure, provided with small vitelline vessels in its mesenchyme layer (pl. 12, fig. 6). The cavity of the yolk sac is lined with a single layer of flattened endodermal cells, which are taller where the omphalopleure is adjacent to the margin of the placenta. The mesenchymal layer of the yolk sac fuses with that of the chorion. It is impossible to determine on this specimen whether the yolk sac is inverted or not.

The *chorion* is in direct contact with the endometrial stroma beneath the placenta, but beyond the placental margin the uterine epithelium is intact (pl. 12, fig. 6). Thus, over the whole decidua parietalis the chorionic epithelium is in contact with the uterine epithelium, a primitive condition.

The amnion covers the fetal surface of the placenta as a part of the inner surface of the gestation sac (pl. 11, fig. 3; pl. 12, fig. 6).

Maternal Circulation in the Placenta

Maternal blood is delivered to the trophoblastic labyrinth through large feeder channels (pl. 11, fig. 4), which are connected with the endometrial arteries of the decidua basalis. These channels have relatively thick trophoblastic walls, and their lumens are lined with the same trophoblastic elements. They are located at one side of the placenta, in the region between the middle and outer thirds of the placental diameter. The channels penetrate the thickness of the placenta to about its center, where they break up into smaller inter-villous trophoblastic channels. Numerous trophoblastic lacunae of various sizes, in the marginal part of the placenta opposite to the feeder channels, collect de-oxygenated maternal blood from the inter-villous trophoblastic channels and return it to the general maternal circulation via the uterine veins. These venous lacunae have thin trophoblastic walls, often composed of a single layer of cells (pl. 11, fig. 5).

DISCUSSION

Our data agree completely with the early work of Hubrecht (1895, 1899) on *Tupaia javanica*. Unfortunately Hubrecht's interest in his material was very specialized (amniogenesis, morphogenesis of the placenta) and covered only a fraction of the broad area used in modern studies of placentation.

Recently van der Horst (1949) attempted to describe the placenta of *Tupaia javanica* and to classify it on the basis of the characteristics of the maternal circulation alone. He states that the maternal channels are lined with endothelium, and therefore refers to these structures as "maternal arteries" surrounded by trophoblast, and interprets the placenta of *Tupaia* as endotheliochorial! The relation between maternal and fetal circulations is nowhere discussed in relation to classification of placental type. Van der Horst concluded that in *Tupaia* "the decaying trophospongia is the main source of food for the developing embryo" and that "the uterine glands also feed the embryo"! This author obviously misunderstood Grosser's classical studies and has contributed nothing to our understanding of placentation in the treeshrews.

The treeshrews (family Tupaiidae) have often been allied with the elephant shrews (family Macroscelididae) in a group usually called the Menotyphla. Most recent students (cf. Simpson, 1945) have denied this relationship, referring the treeshrews to the primates and the elephant shrews to the Insectivora. The only description

of placentation in an elephant shrew is a recent study of *Elephantulus myurus* by van der Horst (1950). We find van der Horst's paper extremely difficult to understand and have relied mainly on his drawings in interpreting his data. The accompanying table summarizes the available data for *Tupaia* and *Elephantulus*. It is evident from the table that the placenta and fetal membranes in these two forms differ in almost every respect except placental type. The labyrinthine hemochorial placental type appears to characterize all insectivores[1] and at least the early stages of rodents; it probably represents a shared primitive feature rather than indicating affinities. Data from the placenta and fetal membranes support the view that the treeshrews and elephant shrews are not closely related.

The fetal adnexa of *Tupaia* are significantly different from those of the Insectivora. In detail the conditions in *Tupaia* represent stages interpreted by students of placentation as more advanced than the corresponding stages represented by the Insectivora. Examples are the vestigial nature of the yolk-sac placenta, the vestigial allantoic vesicle, and the incipient development of villi in the trophoblast. Morphologically, these are differences of degree, and the *Tupaia* condition is easily derivable from the insectivore condition.

What of the supposed relationship of the treeshrews to the primates? The diffuse, non-deciduate, epitheliochorial placenta of the lemurs (both Lemuriformes and Lorisiformes) differs dramatically from that of other primates and closely resembles that of ungulates. This circumstance has been variously interpreted. Some authors (e.g. Hill, 1932) have argued that this is an essentially primitive placental type from which the discoidal, deciduate, hemochorial placenta of the higher primates can be derived. Others (e.g. Wislocki, 1929) have regarded it as a secondarily simplified placenta and therefore useless either as an indicator of the affinities of the lemurs or as representative of a stage in the evolution of the primate placenta. Still others (e.g. Mossman, 1937) have interpreted the placental data literally, maintaining that the lemurs are not primates at all. To us Wislocki's interpretation is the only reasonable one in the light of existing knowledge, which means that the lemurine placenta may be omitted from consideration in the present connection.

On the other hand, the placenta and fetal membranes of *Tupaia* are extraordinarily similar to those of the more generalized members

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[1] Except our term specimen of *Echinosorex*, described elsewhere.

	Elephantulus[1]	Tupaia	Tarsius[2]	Cebidae[2]
Implantation:				
Orientation	mesometrial	bilateral	antimesometrial	antimesometrial
Depth	eccentric	superficial	superficial	superficial
Decidua	capsularis incomplete, disappears early; thick basalis; basal glands large early, degenerate later	no data on capsularis; moderately thick basalis; basal glands atrophic early	no capsularis; thick basalis; basal glands large early, degenerate later	no capsularis; basal glands very large early, almost completely disappear later
Amniogenesis	cavitation	folding (fide Hubrecht)	folding	folding?
Yolk sac:				
Bilaminar omphalopleure	large; no data on persistence	small; no data on persistence	none	none
Chorio-vitelline placenta	large vascular zone at least till limb-bud stage	marginal remnants persist to term	none	none
Vascular splanchnopleure	inverted, large, without villi	incomplete inversion; small and without villi	small free vesicle	vestigial
Chorio-allantoic placenta:				
Shape	single, cup-shaped, stalked	two kidney-shaped structures, unstalked	single, mushroom-shaped, stalked	two disks (one in *Alouatta*), one of which is accessory
Type	labyrinthine, hemochorial	labyrinthine, hemochorial, with villus-like structures	labyrinthine, hemochorial, with villus-like structures	labyrinthine, hemochorial, with more advanced villus-like structures[3]
Allantoic vesicle	medium, reaches placental surface	small, not reaching placental surface	vestigial in mesenchymal body-stalk	vestigial in mesenchymal body-stalk

[1] Authority of van der Horst; data taken largely from his illustrations.

[2] Data from Mossman, after various authors.

[3] Wislocki calls this placental type "trabecular." This is a misleading term; we have shown a trabecular placental structure in a former paper (Fieldiana: Zool., **35**, pl. 7, fig. 12).

of the Cebidae and Cercopithecidae. In almost every detail they represent a condition nearly ideally intermediate between such generalized insectivores as the Tenrecoidea and Erinaceoidea on the one hand, and the more generalized members of the Anthropoidea on the other. The placenta is single in insectivores, double in *Tupaia*, typically double with one element of the pair secondary in the lower monkeys, and single again in the higher anthropoids and man. In *Tupaia* the villous nature of the trophoblast, with villus-like chorionic structures formed around the fetal capillaries, foreshadows the true villous placenta with the wide, open inter-villous spaces and true villi of the higher primates. The size and persistence until the end of gestation of the uterine glands in the decidua basalis seen in *Tupaia* appear to differ only in degree from the conditions seen in the Ceboidea and more primitive cercopithecids. Finally, the other fetal membranes in *Tupaia* are intermediate between the insectivores and the non-lemurine primates. Morphologically the placenta and other fetal membranes of *Tupaia* are almost an ideal starting point from which to derive the corresponding structures of the primates.

These facts are difficult to interpret, whatever significance is assigned to differences in the fetal adnexa, because of the anomalous placenta and fetal membranes of the lemurs. Obviously, placental structures must have evolved, either parallel with or independently of the rest of the organism. Similarities must be due to genetic relationship, to parallelism, or to convergence. The agreement among *Tupaia*, *Tarsius*, and the lower Anthropoidea is so broadly based and detailed that it is unlikely to be due to parallelism or convergence. The alternative requires the assumption that the placenta and fetal membranes of the Lemuriformes (exclusive of the Tupaiidae) and Lorisiformes underwent extensive and radical change *after* these stocks arose, whereas the fetal structures of the Tupaiidae and Tarsiidae have remained relatively unchanged and to this day differ little from those of the most primitive monkeys. We see no alternative conclusion that does not involve far greater improbabilities.

If the lemurs are omitted, the comparative morphology of the fetal adnexa of the insectivores and primates appears to us to parallel the comparative morphology of the adult organisms as closely as could be wished.

SUMMARY

1. The female reproductive organs of *Tupaia minor* are described.

2. The blastocyst and the fetal membranes in a near-term stage of pregnancy are described.

3. Placentation is labyrinthine hemochorial, but with villus-like chorionic structures.

4. The allantois is vestigial and the yolk sac small.

5. The fetal adnexa of *Tupaia* are very different from those of *Elephantulus*.

6. The fetal adnexa of *Tupaia* are in almost every respect intermediate between those of generalized insectivores and those of the more generalized Anthropoidea.

REFERENCES

HILL, J. P.
  1932. The developmental history of the primates.   Phil. Trans. Roy. Soc. London, (B), **221**: 45–178, 17 figs.

HUBRECHT, A. A. W.
  1895. Die Phylogenese des Amnions und die Bedeutung des Trophoblastes. Verh. K. Akad. Wetenschappen Amsterdam, **4**, no. 5, pp. 1–66, 4 pls.
  1899. Über die Entwicklung der Placenta von *Tarsius* und *Tupaja*, nebst Bemerkungen über deren Bedeutung als haematopoietische Organe. Proc. 4th Internat. Congr. Zool., Cambridge, pp. 343–411, pls. 4–15.

JONES, F. W.
  1917. The genitalia of *Tupaia*.   Jour. Anat., (London), **51**: 118–126, 7 figs.

LANGE, DAN. DE, and NIERSTRASZ, H. F.
  1932. Tabellarische Übersicht der Entwicklung von *Tupaia javanica* Horsf. Ontog. der Wirbeltiere in Übersichten, **1**: 1–87, 29 figs., 4 pls.

MEISTER, WALDEMAR, and DAVIS, D. D.
  1953. Placentation of a primitive insectivore, *Echinosorex gymnura*.   Fieldiana: Zool., **35**: 11–26, 1 fig., pls. 4–9.

MOSSMAN, H. W.
  1937. Comparative morphogenesis of the fetal membranes and accessory uterine structures.   Carnegie Inst. Washington, Contr. Embryol., **26**: 128–246, 12 figs., 24 pls.

SIMPSON, G. G.
  1945. The principles of classification and a classification of mammals.   Bull. Amer. Mus. Nat. Hist., **85**, xvi + 350 pp.

VAN DER HORST, C. J.
  1949. The placentation of *Tupaia javanica*.   Proc. K. Akad. Wetenschappen Amsterdam, **52**: 1205–1213, 6 figs.

1950. The placentation of *Elephantulus*. Trans. Roy. Soc. S. Africa, **32**: 435–629, 71 figs.

WISLOCKI, G. B.
1929. On the placentation of primates, with a consideration of the phylogeny of the placenta. Carnegie Inst. Washington, Contr. Embryol., **20**: 51–80, 1 fig., 7 pls.

EXPLANATION OF PLATE 10

FIG. 1. Female urogenital system of *Tupaia minor* in early pregnancy. The left oviduct has been detached from the bursa and extended. Dorsal view. × 3.5.

FIG. 2. Pregnant uterus *in situ;* left horn opened to show placenta. Ventral view. × 1.

1

2
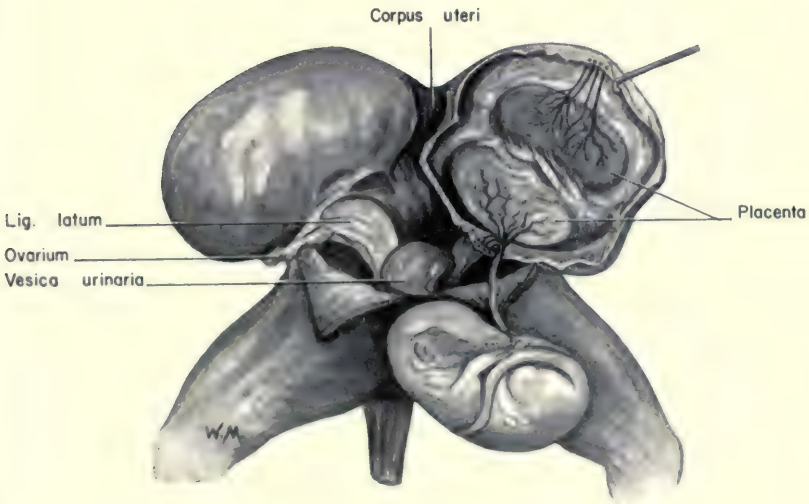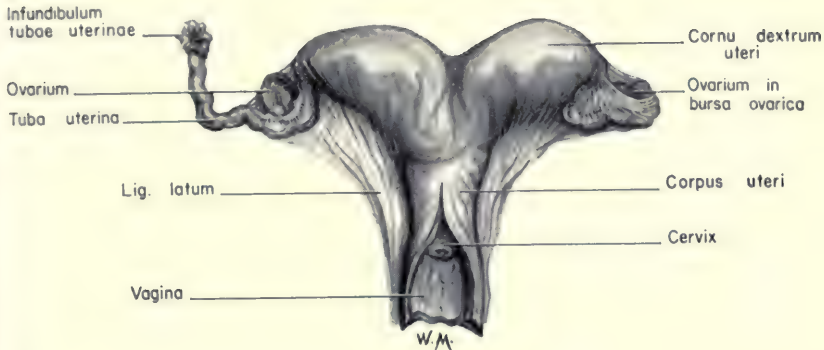
FIG. 3. Section through entire placenta in late fetal stage (see pl. 10, fig. 2). Maternal surface at top, fetal at bottom. The numbered rectangles indicate the approximate sites at which photographs at higher magnification were taken. × 15.

FIG. 4. Maternal arterial feeder channel breaking up into inter-villous trophoblastic channels. The surrounding trophoblast contains numerous villous structures containing fetal capillaries. The thin dark layer of the basal trophoblast is seen at the top. × 100.

FIG. 5. Trophoblastic lacunae collecting venous maternal blood. × 100.
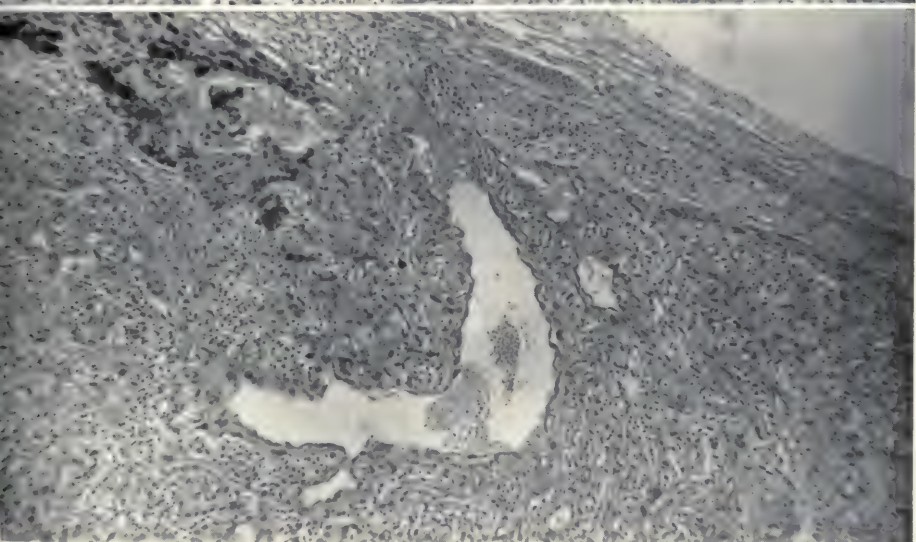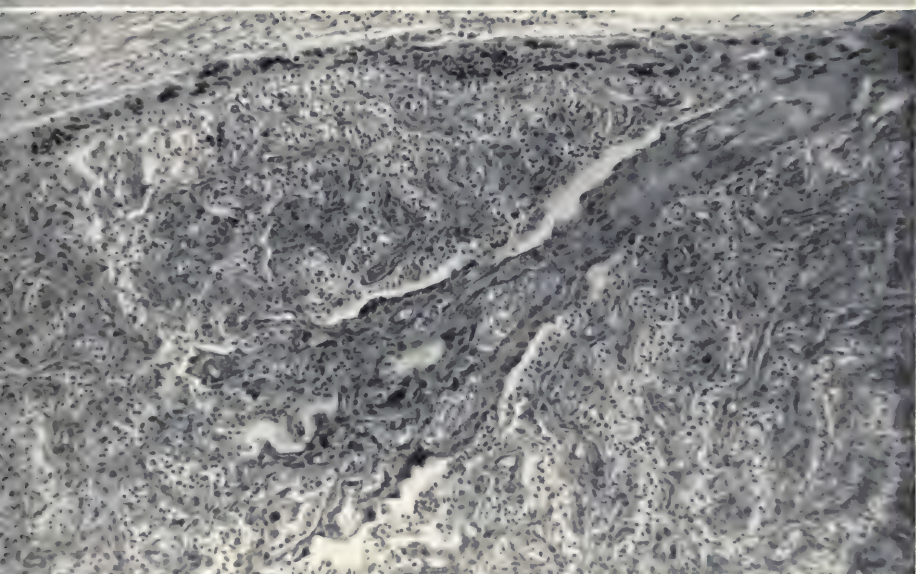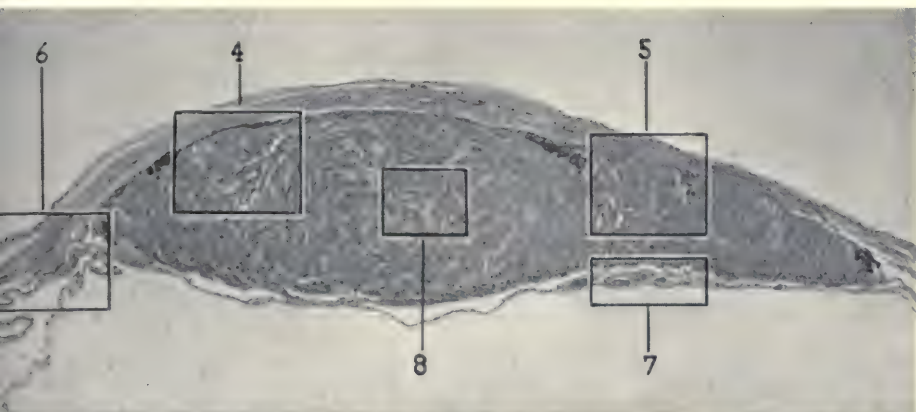
EXPLANATION OF PLATE 12

Fig. 6. Fetal membranes at margin of placenta. *a*, intact uterine epithelium; *b*, chorion; *c*, yolk sac; *d*, amnion. × 112.

Fig. 7. Umbilical vessels at margin of placenta. Artery to the left, vein to the right. × 67.

Fig. 8. Villous structures, composed of fetal capillaries surrounded by chorionic mesenchyme covered with trophoblastic layer; trophoblastic channels filled with maternal blood. × 720.
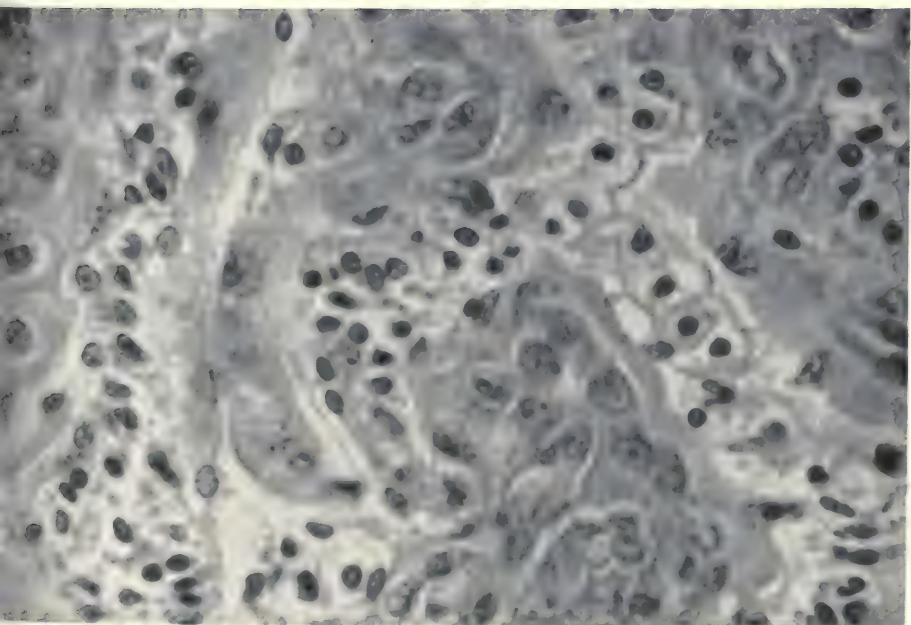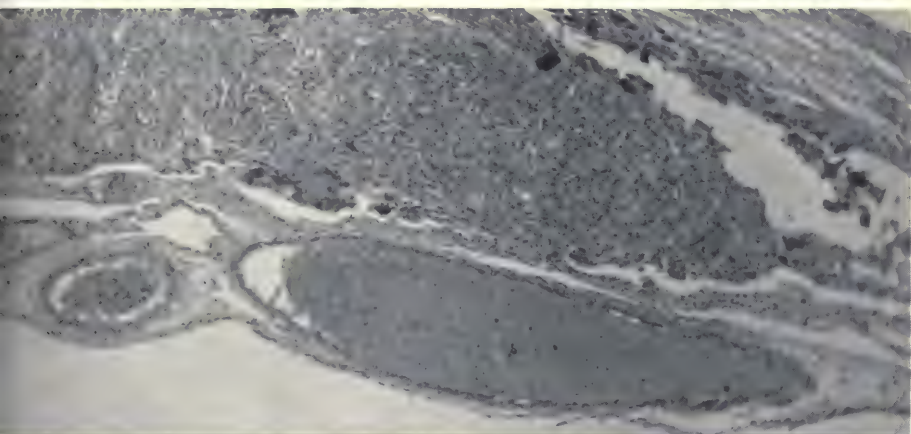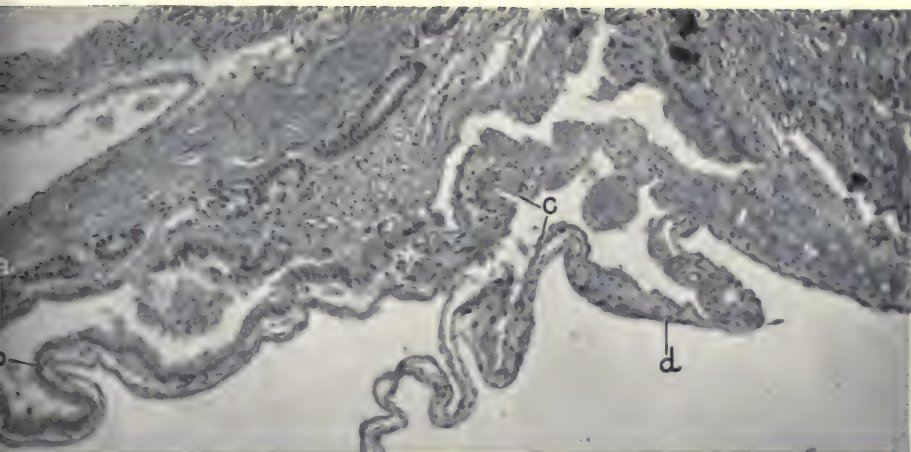
Plate 12

EXPLANATION OF PLATE 13

FIG. 9.   Maternal arterial feeder channel in connection with an endometrial artery.   Atrophic uterine glands are present in the decidua basalis.   × 100.

FIG. 10.   Umbilical arteriole (center) penetrating placenta and breaking up to form the fetal capillaries of the villous structures.   × 100.

FIG. 11.   Section through uterine horn in pre-implantation stage.   Visible are the two trophospongial cushions, one on either side of the uterine lumen, the flattening of the endometrial glands between the trophospongia and the myometrium, and in the myometrium the uterine vessels supplying the trophospongia.   × 36.

FIG. 12.   The same specimen as in figure 11, showing an endometrial artery penetrating into the trophospongia (lower left).   × 100.

FIG. 13.   Remnants of blastocyst in trilaminar stage of development.   Two placental primordia (detached) at top.   Embryonic plate at center, with bilaminar yolk sac beneath.   Portions of extra-embryonic mesoderm, undifferentiated into splanchnopleure and somatopleure, are shown.   × 36.

FIG. 14.   Same as figure 13, showing chorionic membrane connecting the two placental primordia.   × 36.
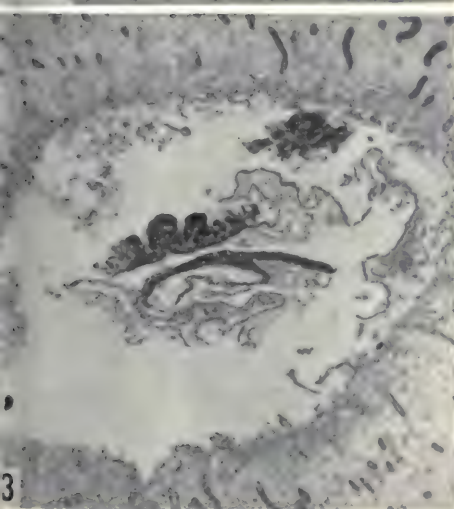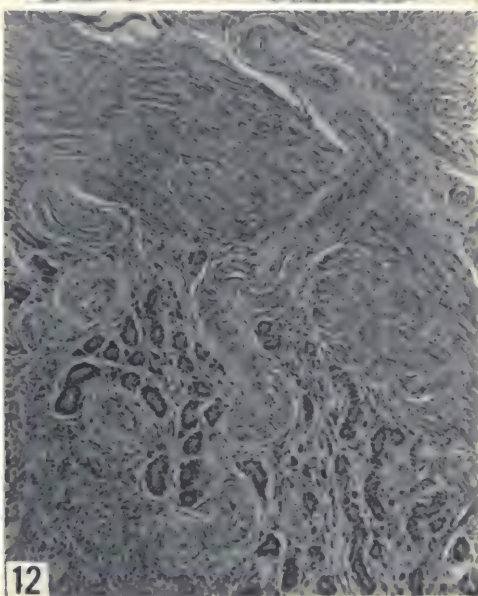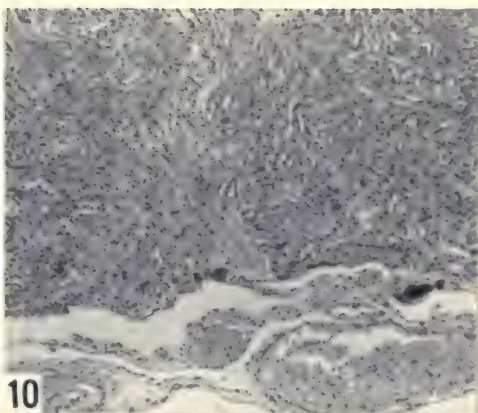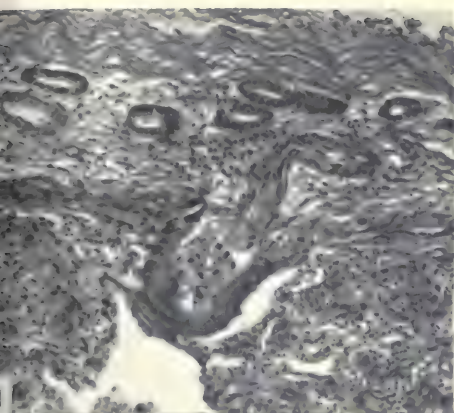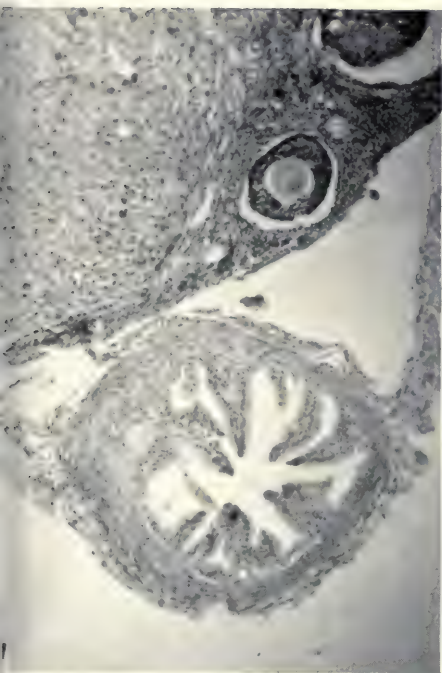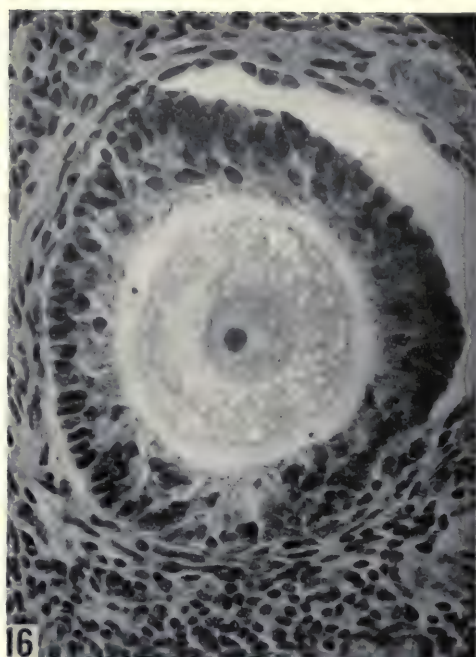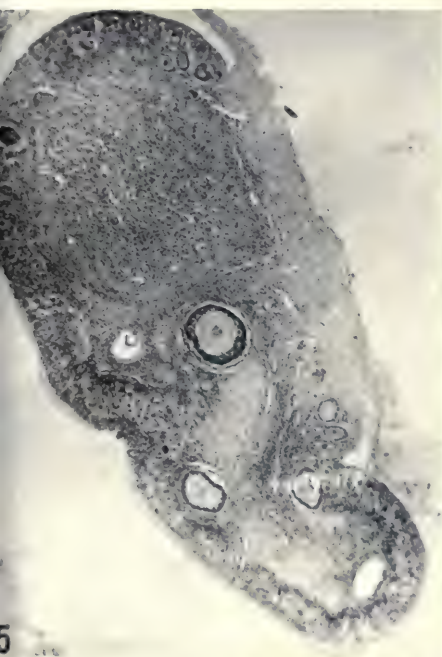
Plate 13

EXPLANATION OF PLATE 14

FIG. 15. Section through ovary at initial stage of pregnancy. The large corpus luteum of pregnancy at the top, and the corpus albicans of a previous pregnancy at the bottom. × 60.

FIG. 16. Tertiary follicle with maturating egg. Two polar bodies are present in the zona pellucida. × 545.

FIG. 17. Section through oviduct enclosed in bursa ovarica, and part of ovary containing corpus luteum of pregnancy. × 75.

FIG. 18. Cross section through umbilical cord. Shown are two arteries (top) and one vein (bottom) and the allantoic duct between the two arteries. × 60.